CHAPTER 1

INTRODUCTION

1.1 Introduction

Nickel-based alloys account for 80% of the superalloy usage within the aerospace industry, with the remainder being iron and cobalt based. Approximately 45–50% of the total material requirements for a gas turbine engine are met using nickel alloys [1]. Other areas of application are within space exploration (main space shuttle engine, nickel–hydrogen batteries (international space station)), power generation (industrial gas turbines), chemical industry (cryogenic tanks), etc. [1–3]. The properties that make nickel-based superalloys attractive to industry are: high yield strength (retained to approximately 750° C), high ultimate tensile strength, high fatigue strength, retention of corrosion and oxidation resistance up to elevated temperatures and good creep resistance [1,4,5].

Numerous publications have shown that nickel based superalloys are difficult to machine regardless of the process being used [6-11]. The properties that make Inconel 718 an important engineering material are also responsible for its generally poor machinability.

Low thermal conductivity (11.4 W/mK) leads to high cutting temperature being developed in the cutting zone. In turning, temperatures of around 900°C have been reported at the relatively low cutting speed of 30 m/min with over 1300°C found at 300 m/min [12]. In addition, temperature gradients in the tool are much steeper than for steels with the maximum temperature being generated in the tool nose region [13]. The materials ability to retain its mechanical properties at elevated temperature results in high cutting forces being generated, around double that found when cutting medium carbon alloy steels. This in combination with the relatively short chip tool contact length means that stress is concentrated on the area of maximum tool temperature leading to chipping and/or plastic deformation of the cutting edge [10, 13]. Nickel based superalloys have a high chemical affinity for many tool materials and as such form an adhering layer leading to diffusion and attrition wear[14]. They are also highly sensitive to strain rate and rapidly work harden causing abrasive wear, particularly at the depth of cut and leading edge positions. The presence of hard phases in the microstructure, such as carbides, nitrides, oxides, etc, further exacerbates tool abrasion.

In contrast to other machining processes drilling has received relatively little attention and most literature available for nickel base superalloys are related only to tool wear and productivity [15]. Drilling is one of the most important processes in aerospace manufacture and being the last operation performed, particular emphasis on the reliability of the process due to the costs already entailed. In addition a hole amplifies the stress around it by a factor of two, placing considerable restraints on dimensional tolerance and hole quality.

1.2 Problem statement

- The metallurgical and mechanical characteristics that give nickel alloys highly valued properties also make them one of the most difficult-to-machine aerospace materials.
- The tendency of nickel alloys to accrue surface damage during machining.
- Burr formation during drilling can increase the cost of manufacturing due to extra time give in removing the burrs.

1.3 Project objective

The objectives of the project are as follows:

- To evaluate the machined hole quality and surface integrity of a Inconel 718 when drilling using carbide drill with respect to surface roughness, microhardness, microstructure defects.
- To study the influence of the cutting conditions on the surface roughness, microstructure defects and burr formation when drilling of Inconel 718.

1.4 Project scope

This study will be focused on drilling of Inconel 718 using uncoated carbide tools. This process is conducted under various independent variables which include cutting speed, feed rate and tool geometries. The surface roughness, microhardness and microstructural changes of subsurface will be evaluated.